Rec'd PCT/PTO 02 FEB 2005 #2
PCT / IB 03 / 03712
31. 07. 03

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Patentanmeldung Nr. | Patent application No. | Demande de brevet n°

02078269.4

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Anmeldung Nr:
Application no.: 02078269.4
Demande no:

Anmeldetag:
Date of filing: 05.08.02
Date de dépôt:

Anmelder/Applicant(s)/Demandeur(s):

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Bezeichnung der Erfindung/Title of the invention/Titre de l'invention:
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Improved sawing process

In Anspruch genommene Prioriät(en) / Priority(ies) claimed /Priorité(s) revendiquée(s)
Staat/Tag/Aktenzeichen/State/Date/File no./Pays/Date/Numéro de dépôt:

Internationale Patentklassifikation/International Patent Classification/
Classification internationale des brevets:

H01L21/00

Am Anmeldetag benannte Vertragstaaten/Contracting states designated at date of filing/Etats contractants désignées lors du dépôt:

AT BE BG CH CY CZ DE DK EE ES FI FR GB GR IE IT LI LU MC NL PT SE SK TR

Improved sawing process

A substantial part of all packaged semiconductor devices is formed from a copper carrier provided with terminals (the so-called (HV)Quad Flat No-lead package), on which copper carrier at least one semiconductor device is present, the bond pads of which being electrically connected to the terminals by means of wire-bonded connections. The semiconductor device(s) and wire-bonded connections are provided with an encapsulation, usually being a glass-filled epoxy.

In general, the sawing of aforementioned copper carrier is done with a dicing apparatus. Handling of the copper carrier is done via a Film Frame Carrier (FFC), which consists of a plastic ring or a metal ring over which a sticky tape is mounted. The copper carrier is placed on the tape, and firmly pressed to ensure adhesion throughout the exposed surface. Then the FFC with copper carrier is transported into the dicing apparatus and set on top of a ceramic vacuum chuck. After aligning the copper carrier using a camera and specially designed alignment features, the copper carrier is sawn in one direction, rotated and subsequently sawn in the direction perpendicular to the one direction. Sawing is done with a dicing blade comprising diamond grains. The dicing blade cuts through both the epoxy encapsulation and the copper carrier along specifically designed lines, so-called sawing lanes, the cutting depth of the blade ending in the tape thereby leaving only a few tens of micrometer tape. During sawing the dicing blade is being cooled with a cooling fluid.
After sawing, the FFC with the singulated packaged semiconductor device(s) is transported out of the sawing area into a cleaning/drying unit, which uses demineralized or tap water and compressed air to remove sawing debris and (blow-)dry the singulated packaged semiconductor device(s). Sawing debris is formed during the sawing process and consists of small particles of epoxy having a size in the range 0-10 micrometers and somewhat larger copper pieces with a size in the range 20-60 micrometers. The whole FFC is subsequently transported into a magazine, and a new FFC is then loaded.
Some remarks with respect to this process are:

- As alternative for FFCs, a chuck (application of a package specific vacuum table) can also be used for transportation of the copper carrier respectively the singulated packaged semiconductor device(s).
- With a certain frequency, the blade wear is measured and the z-position of the blade is adjusted to achieve a same cutting depth for all copper carriers during continuous production. The frequency of this step is dependent on the actual blade wear of the applied sawing process.
- To accommodate the change in blade shape, the above process must be alternated with a so-called truing process, in which dummy material is used to re-shape the blade into its original 0-hrs quality shape by wearing it substantially.
- To remove any copper debris sticking onto the dicing blade, the blade is being worn substantially on a dummy material, thereby removing not only part of the blade but also the debris sticking thereto. This process is called dressing.
- Depending on the process quality, the processing-truing-dressing sequence may be adjusted to achieve highest possible processing time for the involved process.

In the known sawing process as described above, the dicing blade is usually composed of a relatively soft, high wearing matrix of a synthetic material (a so-called resin-bonded blade), which matrix is partially filled with industrial diamond grains, and demineralized water is usually applied as cooling fluid. The water needs however not necessarily be demineralized water. Tap water may also be used. Besides water, the cooling fluid may contain certain surface tension lowering additives for enhancing the cooling effect of the cooling fluid.

A problem of the known sawing process is that the efficiency of the process is low.

In order to solve the problem of the known sawing process, the method in accordance with the present invention is characterized by applying:

- a friction force reducing cooling fluid; and
- a dicing blade of sintered metal with sharp cleaving diamond grains, the sharp cleaving diamond grains being applied in the dicing blade in a concentration smaller than or equal to a maximum concentration, which maximum concentration is defined by the concentration at which the mutual distance between the diamond grains that contribute to the cutting is just large enough to allow removal of substantially all sawing debris.

It has been found experimentally that the method according to the present invention has important advantages over the known method. By using the method of the present invention the blade wear can be reduced significantly thereby increasing the blade lifetime. This method enables an increase in dicing speed while counteracting blade breakage and/or reduction of product quality. The use of this method also enables a reduction of the amount of cooling fluid that is being used. Another advantage is the fact that the dicing blade needs be less frequently dressed which directly results in a significant increase of the sawing process uptime. A further advantage is that the size of the burrs that are present on the singulated packaged semiconductor devices is smaller than obtained with the known method.

If a concentration is selected that is lying above the maximum concentration as defined before, the wear of the blade will be practically nil. Moreover, the burrs appearing on the copper-part of the singulated packaged semiconductor devices will take extreme shapes as is detectable by means of microscopy. Such a high concentration may even result in terminals being thrown out, which is detectable by means of visual inspection. Another effect that probably will take place at such a high concentration is that the dicing blade (completely) silts up with copper.

The sharp cleaving diamond grains are advantageously applied in the dicing blade in a concentration larger than or equal to a minimum concentration, which minimum concentration is defined by the concentration at which the dicing force per diamond grain that contributes to the cutting is just low enough to prevent the diamond grain from breaking out of the dicing blade.

Dicing force can be measured by using a so-called Kistler load cell. However, determination of the dicing force per diamond grain (that contributes to the cutting) is difficult. Nevertheless, other ways are open to a person skilled in the art for determining whether or not he has reached the minimum concentration as defined above. If a concentration is selected that is lying below this minimum concentration, diamond grains will easily break out of the dicing blade thereby leaving holes therein, which holes are detectable by means of microscopy. Furthermore, the blade wear will be extremely high, which is in general measurable with the dicing apparatus itself.

The sharp cleaving diamond grains are advantageously applied with a size in the range from 20 to 60 micrometers. An emulsion of a sawing oil in water is advantageously used as the friction force reducing cooling fluid, the sawing oil having the function of reducing the friction forces being applied with advantage in a volume percentage in the range from 1 to 10. Natural sharp cleaving diamond grains are advantageously used as the diamond grains. As metal carrier advantageously a ductile metal carrier is applied, such as a copper carrier. The encapsulation advantageously comprises epoxy.

Further advantageous embodiments of the method in accordance with the invention are represented by the following measures, taken individually or in combination:

- Apply a copper carrier with a design that is symmetrical along the sawing lanes. This measure counteracts asymmetrical wear of the dicing blade. In other words, the wear at one side of the blade' s cutting edge will remain substantially the same as that at the other side of the blade' s cutting edge. A more symmetrical blade wear enables a better alignment of the dicing blade during sawing.
- Counteract sawing of the side rail (part of the copper carrier that is not covered with epoxy) by carrier design or removal thereof beforehand. Sawing of pure copper results in extra blade wear owing to the ductility of the copper material.
- Use minimal amount of copper in the sawing lanes. As the amount of copper to be sawn per unit of sawing length is decreased, the blade wear per unit of sawing length is reduced.

Experiments have shown that:

- Reduction of blade wear is not realized with resin-bonded blades combined with (demineralized) water as cooling fluid. The blades in this known sawing process show a wear of about 50-300 µm/meter sawing length, whereas by using the sawing process according to the present invention a wear of about 1-2 µm/meter sawing length can be realized;
- Use of the dicing blades of the sawing process according to the present invention combined with (demineralized) water leads to breakage of the dicing blades; and
- Use of the resin-bonded blades of the known sawing process combined with the friction force reducing cooling fluid of the sawing process according to the present invention does also not give the desired effect.

The present invention further relates to a dicing apparatus for subjecting a metal carrier provided with at least one semiconductor device that is provided with an encapsulation to a singulation step, in which singulation step a dicing blade cuts, while being cooled with a cooling fluid, through the encapsulation and the metal carrier so as to singulate the at least one semiconductor device, the dicing apparatus comprising

- means for supplying a friction force reducing cooling fluid; and
- a dicing blade of sintered metal with sharp cleaving diamond grains, the sharp cleaving diamond grains being applied in the dicing blade in a concentration smaller than or equal to a maximum concentration, which maximum concentration is defined by the concentration at which the mutual distance between the diamond grains that contribute to the cutting is just large enough to allow removal of substantially all sawing debris.

It will be apparent that the invention is not limited to the embodiments described above, but that many variations are possible to those skilled in the art within the scope of the invention.

CLAIMS:

1. A method of manufacturing a packaged semiconductor device comprising subjecting a metal carrier provided with at least one semiconductor device, the semiconductor device being provided with an encapsulation, to a singulation step in a dicing apparatus that is provided with a dicing blade comprising diamond grains, in which singulation step the dicing blade cuts, while being cooled with a cooling fluid, through the encapsulation and the metal carrier so as to singulate the at least one semiconductor device, characterized by applying
- a friction force reducing cooling fluid; and
- a dicing blade of sintered metal with sharp cleaving diamond grains, the sharp cleaving diamond grains being applied in the dicing blade in a concentration smaller than or equal to a maximum concentration, which maximum concentration is defined by the concentration at which the mutual distance between the diamond grains that contribute to the cutting is just large enough to allow removal of substantially all sawing debris.

2. A method as claimed in claim 1, characterized by applying the sharp cleaving diamond grains in the dicing blade in a concentration larger than or equal to a minimum concentration, which minimum concentration is defined by the concentration at which the dicing force per diamond grain that contributes to the cutting is just low enough to prevent the diamond grain from breaking out of the dicing blade.

3. A method as claimed in claim 1 or 2, characterized by applying the metal carrier with a design that is symmetrical along sawing lanes along which the dicing blade cuts.

4. A method as claimed in any one of the preceding claims, characterized by applying the sharp cleaving diamond grains with a size in the range from 20 to 60 micrometers.

5. A method as claimed in any one of the preceding claims, characterized by applying a ductile metal carrier.

6. A method as claimed in claim 5, characterized by applying a copper carrier.

7. A method as claimed in any one of the preceding claims, characterized by applying an emulsion of a sawing oil in water as the friction force reducing cooling fluid.

8. A method as claimed in claim 7, characterized by applying the sawing oil in a volume percentage in the range from 1 to 10.

9. A method as claimed in any one of the preceding claims, characterized by applying natural sharp cleaving diamond grains.

10. A method as claimed in any one of the preceding claims, characterized by applying an epoxy encapsulation.

11. A dicing apparatus for subjecting a metal carrier provided with at least one semiconductor device that is provided with an encapsulation to a singulation step, in which singulation step a dicing blade cuts, while being cooled with a cooling fluid, through the encapsulation and the metal carrier so as to singulate the at least one semiconductor device, the dicing apparatus being characterized by

- means for supplying a friction force reducing cooling fluid; and
- a dicing blade of sintered metal with sharp cleaving diamond grains, the sharp cleaving diamond grains being applied in the dicing blade in a concentration smaller than or equal to a maximum concentration, which maximum concentration is defined by the concentration at which the mutual distance between the diamond grains that contribute to the cutting is just large enough to allow removal of substantially all sawing debris.

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